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STUDY ON SPECTRAL/RADIOMETRIC CHARACTERISTICS OF THE THEMATIC MAPPER FOR LAND USE APPLICATIONS

21 September 1983 — 20 December 1983

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16. Abstract

Progress during ERIM's fifth quarter of effort under the Landsat-4 Image Data Quality Assessment program for the Thematic Mapper is described.

Our previous characterization of scan-related low-frequency noise was confirmed and extended through analysis of reflective-band data from another nighttime acquisition. Amplitude and phase relationships of the level shifts were determined for each detector in each of three full frames.

Analysis of scan-direction-related signal droop effects in nighttime data from the reflective bands was begun with encouraging initial observations. Also, an effort to characterize high-frequency noise in the reflective bands through Fourier analysis of nighttime data was initiated.

Also, recommendations are made relative to the choice of radiometric calibration constants in the TIPS (Thematic Mapper Image Processing System) for the routine processing of TM data. Non-linear (piece-wise linear) calibration curves are recommended.

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under

Contract NAS5-27346

with

NASA Goddard Space Flight Center
Greenbelt Road
Greenbelt, Maryland 20771

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Distribution

Fifth Quarterly Report

STUDY ON SPECTRAL/RADIOMETRIC CHARACTERISTICS OF THE THEMATIC MAPPER FOR LAND USE APPLICATIONS

1. OBJECTIVE

The objective of this investigation is to quantify the performance of the TM as manifested by the quality of its image data, in order to suggest improvements in data production and to assess the effects of the data quality on its utility for land resources applications. Three categories of this analysis are: a) radiometric effects, b) spatial effects and c) geometric effects, with emphasis on radiometric effects.

2. TASKS

Four tasks have been established to address the above objective. The first three are to study radometric performance, spatial performance and geometric performance, respectively, while the fourth is to study spectral characteristics. In keeping with the identified objective, the radiometric performance study is the major task.

3. STATUS AND TECHNICAL PROGRESS

During this fifth quarterly reporting period, work was continued on our study of the radiometric performance of TM. Additional characterization of scan-related level-shift noise in TM reflective-band data was achieved through analyses of non-thermal data from night scenes. Two other analysis efforts utilizing the nighttime data were initiated. The first is a resumption of our earlier analysis of scan-direction-related signal droop effects and the second is an examination of high-frequency noise within scan lines. Also we responded to a request for inputs by making recommendations for the procedure used in TIPS (Thematic Mapper Image Processing System) to radiometrically calibrate TM data prior to their distribution. Also, technical presentations were made at the Pecora VIII Symposium and the December LIDQA Investigators' Workshop. A paper was prepared and accepted for publication in the IEEE Transactions on Geoscience and Remote Sensing.

3.1 PROBLEMS

None.

3.2 ACCOMPLISHMENTS

Accomplishments in four technical areas are described below.

3.2.1 ANALYSIS OF LOW-FREQUENCY LEVEL-SHIFT NOISE

As reported previously, examination of nighttime reflective-band data from the Augusta night scene proved very fruitful in analysis of low-frequency level-shift noise. Analysis of the Buffalo night scene during this quarter provided further insight into the characteristics of that noise. In this scene, the Form #1 noise (most evident in Band 1 Detectors 4, 12, 10, and 8) is absent, while the Form #2 noise (exemplified by Band 7 Detector 7) is present to the same extent observed in other scenes. In the seven scenes we have examined, Form #2 noise is always present, and Form #1 is present in most, but not all, scenes (See Table 1). The peak-to-peak amplitude for each detector for each form of the noise is essentially constant in all cases where that form of the noise exists. The phase relationships between the affected detectors also remain constant in all images (i.e., Band 7 Detector 7 is always in its "high" state when Band 5 Detector 8 is in its "low" state). Tables 2, 3, and 4 list the magnitude and phase of each form of the noise for Scenes 40037-02243, 40049-16262, and 40161-02481, respectively. The poorer separation of states shown for Frame 40049-16262 is due to the fact that these tables were made from scene radiometric data, and this scene was the only daytime scene of the three.

3.2.2 ANALYSIS OF SCAN-DIRECTION-RELATED SIGNAL DROOP EFFECT

Initial analysis of the nighttime reflective data for signal droop effects is promising. Although the magnitude of the droop is quite small at these low signal levels, it is clearly and consistently there.

Further efforts directed at characterizing the effect and proposing a solution are planned.

3.2.3 ANALYSIS OF HIGH-FREQUENCY NOISE

The success in quantifying the low-frequency noise through the use of night data suggested its potential value in analysis of the high-frequency noise reported earlier by other investigators. Analysis of fast Fourier transform data is still underway, with preliminary results supporting previous findings of components with wavelengths of $\sim$3.24 pixel widths (32.1 KHz) and 13.67 pixel widths (7.61 KHz).

3.2.4 RADIOMETRIC CALIBRATION PROCEDURE FOR TIPS PROCESSING OF TM DATA

One step in the calculation of Radiometric Look-up Tables (RLUT's) for converting received sensor signals into digital counts on radiometrically corrected computer-compatible digital tapes (CCT's), utilizes absolute calibration information. As the sensor response changes, the number of radiometric units per raw data count changes. However, the desire is to have a consistent number of radiometric units per CCT digital count in each band. A special meeting was called by Dr. John Barker during the December 1983 LIDQA Investigators' Workshop; W. Malila and M. Metzler of ERIM attended the meeting. Dr. Barker briefly reviewed for the assembled group the history of maximum radiance (R_{max}) values that (a) had been used in SCROUNGE processing of TM data during the first year, (b) have been used in subsequent processing by TIPS, the Thematic Mapper Image Processing System, (c) are proposed for the next update of TIPS, and (d) may be used for Landsat-5 data. He asked for comments on the suitability of the proposed values (or approach for their selection) and any other suggestions.

Because of conflicting user requirements, there is not a clear-cut choice. Figure 1 helps illustrate the problem through lines representing use of two different R_{max} values for the linear relationships currently in use. (R_{min} values equal to zero are assumed for simplicity in the example.) The line with the larger R_{max} value covers a greater range of signal radiance values but, because the number of digital counts remains the same, produces a coarser quantization of radiances (more radiance units per digital count). A large radiance range is desired by those researchers interested in mapping snow, clouds, and other bright scene materials and by Landsat systems people who wish to allow for possible different responsivity in the Landsat-5 Thematic Mapper. On the other hand, a finer quantization of radiances is desired by the majority of investigators, who are not concerned with accurate representation of radiances from bright objects, and particularly by those investigators with bathymetry and other applications for which low signal values are of prime interest.

Dr. W. Malila made a suggestion in the meeting that consideration be given to use of non-linear (perhaps piecewise-linear) calibration curves rather than the simple linear relationships that have been employed up to this point in time. Figure 2 illustrates a two-piece curve that has the following features: (a) radiances up to the relatively high R_{max2} value can be represented and (b) the finer quantization associated with R_{max1} can apply to the majority of data values. The sacrifices are a large radiance quantization unit for the high

range of signal values (larger even than that associated with R_{max2} and the simple linear relationship of Figure 1) and a loss of the simple linear relationship. To specify the curve, only the two end points and the break point need be identified, e.g., (S_0,L_0), (S_1,L_1), and (S_2,L_2) on Figure 2(b).

In discussing the meeting with Mr. Fred Tanis and others at ERIM who are involved in bathymetry studies, the desirability for a three-piece curve having a modified low-radiance response characteristic was identified. The illustration in Figure 3(a) has the shallowest slope (most responsive, i.e., most counts per radiance unit) for low radiance values, the moderate slope (comparable to the original simple linear relationship) for mid-range values, and the steepest slope (least responsive, i.e., fewest counts per radiance unit) for high radiance values. This type of response characteristic can be specified by giving the two end points and the two intermediate break points, as shown in Figure 3(b).

If two- or three-piece characteristics are adopted for generating the radiometric lookup tables, the appropriate end points and break points should be identified in the headers of CCT's produced by TIPS. One other piece of information should also be included if any detectors are more responsive than the selected response characteristics for the band. This added information would be the signal count level (after correction) which corresponds to saturation of the raw detector output.

3.3 SIGNIFICANT RESULTS

See Sections 3.2 and 3.5.

3.4 PUBLICATIONS AND PRESENTATIONS

A paper was presented at the Pecora VIII Symposium held in Sioux Falls, SD, on October 4-7, 1983, in the session on Landsat 4 results. Entitled "Radiometric Analyses of Landsat-4 Digital Image Data", by William Malila, Daniel Rice and Michael Metzler, the paper was presented by W. Malila. A written paper was submitted for publication in the symposium proceedings.

William Malila and Michael Metzler attended the LIDQA Investigators' Workshop at NASA/GSFC on 6-7 Dec 83. W. Malila presented a summary of ERIM's now-completed MSS investigation for LIDQA (Contract NAS5-27254), while M. Metzler presented an update of our TM efforts under this contract.

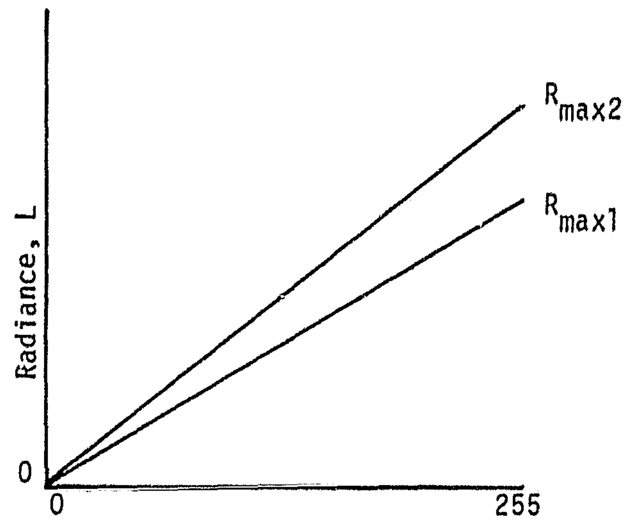
A paper describing results of these investigations was written and accepted for publication in the May 1984 issue of the IEEE Transactions on Geoscience and Remote Sensing. Entitled "Characterization of Landsat-4 MSS and TM Digital Image Data", it was co-authored by William A. Malila, Michael D. Metzler, Daniel P. Rice, and Eric P. Crist.

3.5 RECOMMENDATIONS

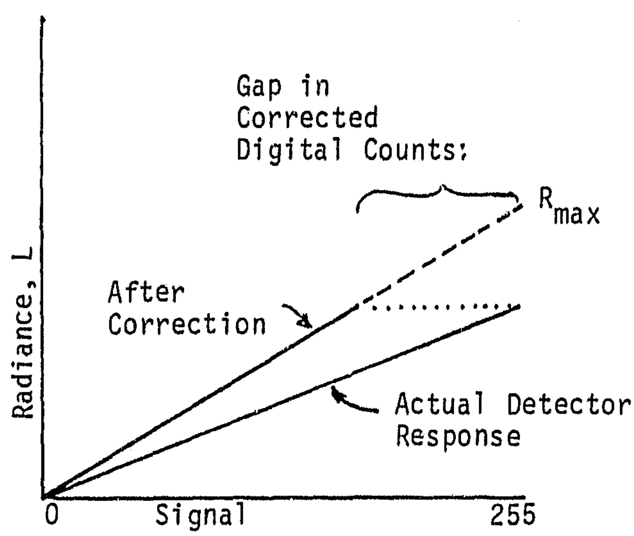
As discussed in Section 3.2.4, it is recommended that NASA implement a two- or three-piece (the latter being preferable) piecewise-linear calibration characteristic for radiometrically calibrating TM data in TM ground segment (TIPS). This would avoid unnecessary saturation of output values and enhance low-radiance responses, while providing for flexibility for accommodating Landsat-5 TM data.

3.6 FUNDS EXPENDED

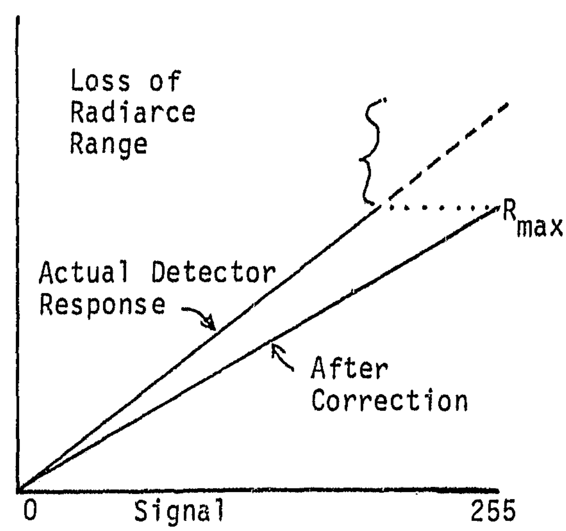
A total of approximately $20,600 was expended during the three months September through November 1983. The cumulative spending through November represents approximately 54% of the total contract award and 77% of the funds allocated. Expenditures during the period 1-20 December 1983 are not included in these percentages.



(a) Effect of R_{max} Value



(b) Detector More Responsive Than Standardized Response



(c) Detector Less Responsive Than Standardized Response

FIGURE 1. ILLUSTRATIONS OF RADIOMETRIC CALIBRATION USING SIMPLE LINEAR RESPONSE CHARACTERISTIC

ORIGINAL PAGE IS OF POOR QUALITY

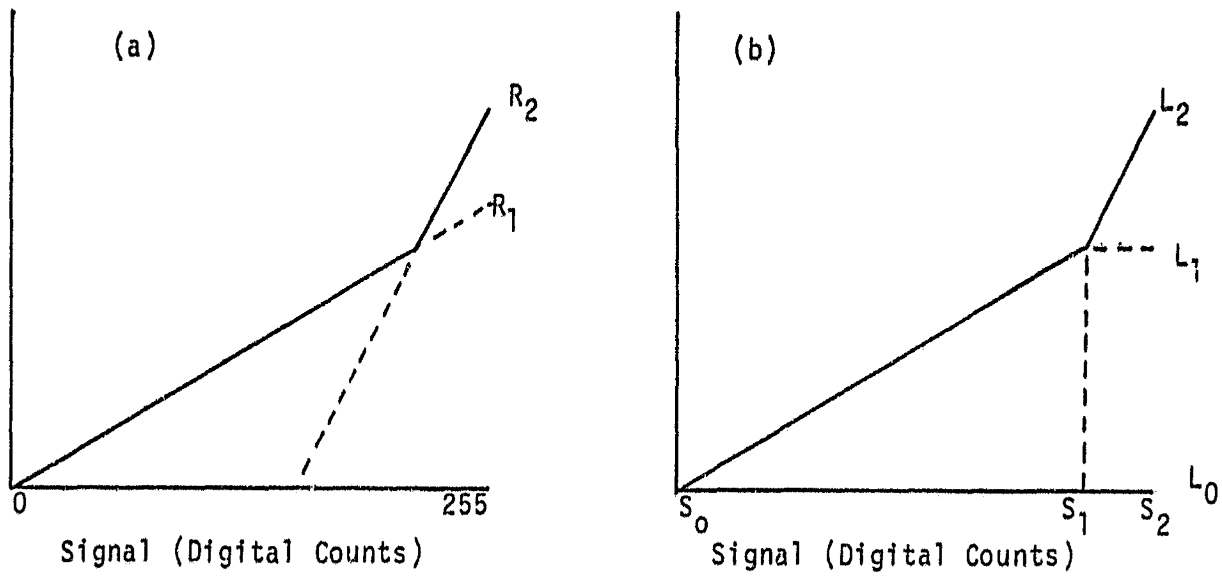


FIGURE 2. ILLUSTRATIONS OF TWO-PIECE PIECEWISE-LINEAR RESPONSE CHARACTERISTIC

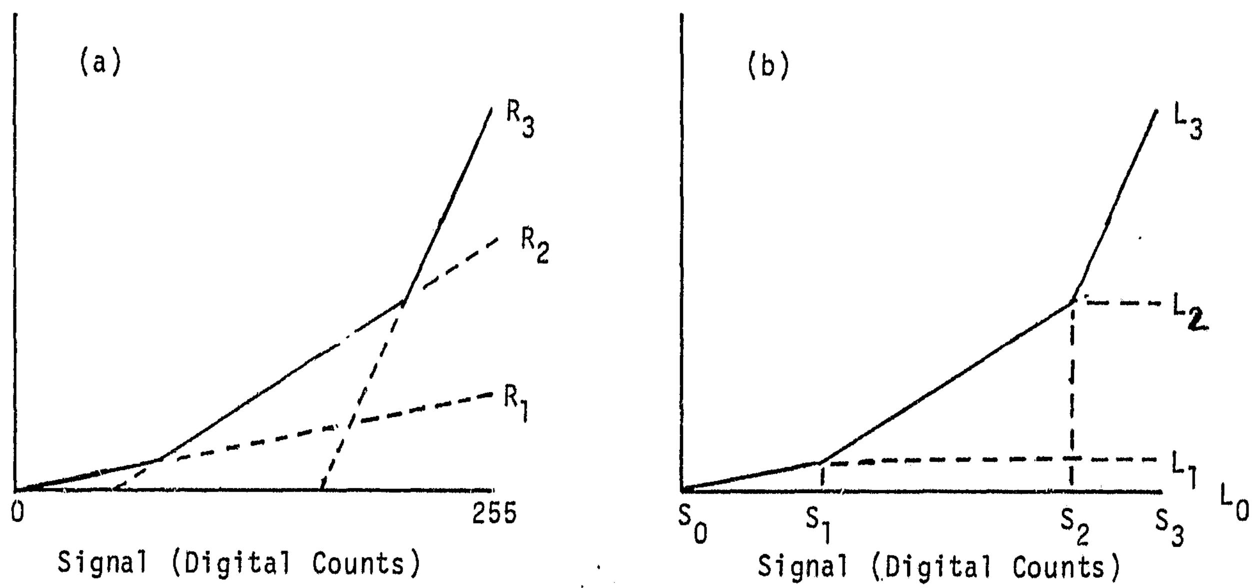


FIGURE 3. ILLUSTRATIONS OF THREE-PIECE PIECEWISE-LINEAR RESPONSE CHARACTERISTIC

Table 1. Presence of Low-Frequency Level Shifts in TM Data

Location	Date	Scene ID	Form 1	Form 2
Arkansas	22 Aug	40037-16034	yes	yes
Buffalo	22 Aug (PM)	40037-02243	no	yes
Iowa	3 Sep	40049-16262	yes	yes
N. Carolina	24 Sep	40070-15084	yes	yes
Cape Cod	8 Dec	40145-14492	yes	yes
Georgia	24 Dec (PM)	40161-02481	yes	yes (periodic)
Grand Bahamas	14 Jan	40182-15125	no	yes (periodic)

Table 2. Magnitude of Level Shifts for Night Scene 40037-02243

Band	Det	Amplitude Form 1	Amplitude Form 2	Separation of States (#S.D.) Form 1	Separation of States (#S.D.) Form 2
1	1	0.026	-0.218	.3	2.6
1	2	0.047	-0.196	.8	3.6
1	3	0.029	-0.168	.4	2.6
1	4	0.032	0.040	.4	.6
1	5	0.022	-0.190	.4	3.2
1	6	0.045	-0.044	.8	.8
1	7	0.023	-0.118	.4	2.1
1	8	0.041	-0.084	.7	1.6
1	9	0.035	-0.005	.5	.1
1	10	0.042	-0.062	.8	1.2
1	11	0.039	-0.119	.5	1.8
1	12	0.026	-0.061	.4	1.0
1	13	0.035	-0.096	.4	1.2
1	14	0.042	-0.126	.7	2.1
1	15	0.039	-0.127	.4	1.3
1	16	0.052	-0.096	.7	1.3
2	1	0.029	-0.383	.5	6.1
2	2	0.036	0.049	.5	1.4
2	3	0.035	-0.259	.7	5.1
2	4	0.027	0.019	.9	.7
2	5	0.026	-0.166	.7	4.6
2	6	0.036	0.033	.9	.9
2	7	0.022	-0.114	.6	3.4
2	8	0.035	0.047	.7	1.0
2	9	0.025	-0.073	.9	2.6
2	10	0.021	0.024	.9	1.1
2	11	0.028	-0.108	.7	2.8
2	12	0.026	0.032	.8	1.1
2	13	0.031	-0.125	.8	3.3
2	14	0.024	0.032	1.0	1.4
2	15	0.023	-0.119	.7	3.7
2	16	0.030	0.122	1.0	4.3
3	1	-0.013	-0.602	.4	7.0
3	2	0.027	0.270	.8	8.0
3	3	0.012	-0.338	.2	6.0
3	4	0.022	0.029	.8	1.1
3	5	0.019	-0.228	.4	5.1
3	6	0.026	0.072	.8	2.3
3	7	0.017	-0.232	.4	5.3
3	8	0.027	-0.050	.7	1.4
3	9	0.030	-0.111	.7	2.6
3	10	0.029	0.039	.7	1.0
3	11	0.012	-0.143	.4	5.0
3	12	0.021	0.177	.6	4.7
3	13	0.013	-0.187	.3	4.5
3	14	0.031	0.171	.8	5.1
3	15	0.010	-0.290	.2	5.5
3	16	0.037	0.877	.4	10.5
4	1	0.026	-0.078	.7	2.1
4	2	0.023	-0.082	.7	2.5
4	3	0.041	-0.049	.7	.8
4	4	0.026	-0.082	.7	2.5
4	5	0.015	-0.023	.7	1.3
4	6	0.034	-0.077	.6	1.6
4	7	0.011	-0.018	.7	1.3
4	8	0.022	-0.102	.7	3.1
4	9	0.014	-0.022	.7	1.1
4	10	0.012	-0.015	.8	1.0
4	11	0.006	-0.011	.6	1.2
4	12	0.012	0.003	.6	.2
4	13	0.003	-0.006	.6	1.2
4	14	0.009	-0.017	.6	1.1
4	15	0.005	-0.008	.6	1.1
4	16	0.005	0.003	.7	.4
5	1	0.003	0.063	.1	1.5
5	2	0.004	-0.103	.1	2.0
5	3	-0.005	-0.091	.2	3.7
5	4	0.001	-0.037	.2	.8
5	5	-0.001	-0.056	.1	1.6
5	6	0.000	-0.076	.2	2.2
5	7	0.002	0.163	.1	3.7
5	8	-0.000	-0.212	.0	6.5
5	9	-0.001	0.026	.1	.7
5	10	0.002	0.739	.1	19.4
5	11	0.001	0.044	.1	1.6
5	12	0.001	0.065	.2	2.3
5	13	0.000	0.002	.2	.2
5	14	-0.000	-0.083	.2	3.8
5	15	0.003	-0.139	.1	4.8
5	16	0.005	-0.101	.2	4.1
7	1	0.003	0.313	.2	9.2
7	2	0.005	-0.298	.1	7.2
7	3	0.003	0.343	.2	6.8
7	4	0.004	-0.263	.2	7.3
7	5	0.002	0.295	.1	9.6
7	6	0.004	-0.289	.3	6.7
7	7	0.006	0.977	.1	6.2
7	8	0.003	-0.346	.2	10.5
7	9	-0.000	0.200	.1	6.3
7	10	0.002	-0.451	.3	11.0
7	11	0.002	0.247	.1	7.7
7	12	0.003	-0.280	.3	5.6
7	13	-0.001	0.237	.2	5.5
7	14	0.003	-0.062	.1	1.9
7	15	0.003	0.211	.2	9.0
7	16	0.008	-0.237	.3	5.4

** Negative amplitudes indicate level shifts with phase shifts of 180 deg. relative to B1D4 (Form 1) or B7D7 (Form 2).

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Table 3. Magnitude of Level Shifts for Scene 40049-16262

Band	Det	Amplitude Form 1	Amplitude Form 2	Separation of States (#S.D.) Form 1	Separation of States (#S.D.) Form 2	Band	Det	Amplitude Form 1	Amplitude Form 2	Separation of States(#S.D.) Form 1	Separation of States(#S.D.) Form 2
1	1	0.275	-0.185	.9	.6	4	1	0.264	-0.055	1.2	.3
1	2	-0.016	-0.169	.1	.6	4	2	0.215	-0.138	.7	.4
1	3	0.103	-0.136	.4	.5	4	3	0.163	-0.044	.6	.2
1	4	1.975	0.053	7.3	.2	4	4	0.049	-0.086	.2	.4
1	5	0.111	-0.161	.4	.7	4	5	0.228	-0.060	.8	.2
1	6	0.073	-0.040	.3	.2	4	6	0.258	-0.057	1.2	.2
1	7	0.078	-0.087	.2	.3	4	7	0.175	-0.051	.6	.2
1	8	0.633	-0.083	2.8	.4	4	8	0.013	-0.131	.1	.6
1	9	0.137	0.032	.5	.1	4	9	0.180	-0.091	.6	.3
1	10	0.954	-0.045	4.0	.2	4	10	0.326	-0.026	1.5	.1
1	11	0.134	-0.078	.5	.3	4	11	0.271	-0.062	1.2	.3
1	12	1.741	-0.039	7.3	.2	4	12	0.700	0.018	3.9	.1
1	13	0.325	-0.023	1.3	.1	4	13	0.260	-0.036	1.6	.2
1	14	0.169	-0.116	.6	.4	4	14	0.368	-0.077	1.6	.3
1	15	0.193	-0.088	.6	.3	4	15	0.347	-0.050	1.8	.3
1	16	-0.027	-0.109	.1	.5	4	16	0.701	0.026	3.9	.1
2	1	0.222	-0.300	1.6	2.1	5	1	-0.038	0.063	.2	.3
2	2	0.166	0.055	.9	.3	5	2	0.146	-0.104	.6	.4
2	3	-0.089	-0.244	.6	1.5	5	3	-0.150	-0.079	.9	.4
2	4	0.221	0.039	1.3	.2	5	4	0.128	-0.044	.6	.2
2	5	0.070	-0.180	.4	1.1	5	5	-0.194	-0.033	.9	.2
2	6	0.103	0.059	.7	.4	5	6	0.075	-0.087	.4	.4
2	7	-0.018	-0.146	.1	.9	5	7	-0.012	0.129	.0	.5
2	8	0.133	0.051	.8	.3	5	8	-0.035	-0.231	.2	1.1
2	9	0.054	-0.095	.4	.7	5	9	-0.121	0.018	.5	.1
2	10	0.088	0.074	.6	.5	5	10	-0.035	0.766	.2	3.5
2	11	-0.001	-0.114	.1	.8	5	11	-0.060	0.062	.2	.3
2	12	0.046	0.033	.3	.2	5	12	0.058	0.047	.3	.2
2	13	0.131	-0.153	.9	1.0	5	13	-0.103	-0.016	.4	.1
2	14	0.198	0.058	1.3	.4	5	14	0.003	-0.098	.0	.5
2	15	0.135	-0.167	.8	1.0	5	15	-0.245	-0.123	1.1	.6
2	16	0.148	0.154	1.0	1.1	5	16	0.041	-0.118	.2	.6
3	1	0.528	-0.579	2.3	2.6	7	1	-0.023	0.360	.1	1.7
3	2	0.294	0.333	1.8	2.0	7	2	0.022	-0.336	.1	1.5
3	3	0.243	-0.322	1.5	2.0	7	3	-0.071	0.393	.3	1.8
3	4	0.031	0.045	.2	.3	7	4	0.076	-0.327	.3	1.4
3	5	0.332	-0.257	2.0	1.5	7	5	0.008	0.324	.1	1.5
3	6	0.279	0.096	1.7	.6	7	6	0.114	-0.362	.5	1.6
3	7	0.189	-0.248	1.0	1.4	7	7	-0.012	0.964	.0	1.4
3	8	-0.077	-0.033	.5	.2	7	8	0.069	-0.422	.4	2.3
3	9	-0.030	-0.110	.2	.7	7	9	-0.094	0.239	.5	1.1
3	10	0.315	0.091	1.8	.5	7	10	0.103	-0.528	.4	2.3
3	11	0.094	-0.176	.7	1.3	7	11	-0.055	0.293	.2	1.3
3	12	0.202	0.230	1.2	1.3	7	12	0.216	-0.332	.9	1.4
3	13	0.316	-0.216	2.1	1.4	7	13	-0.078	0.279	.4	1.3
3	14	0.302	0.202	1.7	1.1	7	14	0.184	-0.074	.8	.3
3	15	0.384	-0.385	2.1	2.1	7	15	-0.026	0.265	.1	1.4
3	16	0.475	0.907	2.7	5.2	7	16	0.185	-0.291	.8	1.3

** Negative amplitudes indicate level shifts with phase shifts of 180 deg. relative tc B1D4 (Form 1) or B7D7 (Form2).

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Table 4. Magnitude of Level Shifts for Night Scene 40161-02481

Band	Det	Amplitude Form 1	Amplitude Form 2	Separation of States (#S.D.) Form 1	Separation of States (#S.D.) Form 2
1	1	0.261	-0.162	3.1	1.9
1	2	-0.024	-0.188	.3	2.5
1	3	0.077	-0.117	1.1	1.7
1	4	1.880	0.116	26.2	1.6
1	5	0.120	-0.141	2.1	2.4
1	6	0.038	-0.060	.5	.8
1	7	0.098	-0.077	1.6	1.2
1	8	0.569	-0.092	8.0	1.3
1	9	0.146	0.043	2.0	.6
1	10	0.877	-0.053	13.2	.8
1	11	0.173	-0.063	2.1	.8
1	12	1.601	-0.011	24.3	.2
1	13	0.313	-0.029	3.8	.3
1	14	0.084	-0.124	1.2	1.8
1	15	0.171	-0.041	1.8	.4
1	16	-0.025	-0.123	.3	1.6
2	1	0.246	-0.323	4.0	5.2
2	2	0.149	0.056	3.0	1.1
2	3	-0.082	-0.202	1.2	3.0
2	4	0.203	0.027	5.0	.7
2	5	0.072	-0.138	1.4	2.7
2	6	0.075	0.056	1.4	1.1
2	7	0.004	-0.086	.1	2.0
2	8	0.106	0.062	1.8	1.1
2	9	0.039	-0.053	1.3	1.8
2	10	0.033	0.031	1.3	1.2
2	11	0.056	-0.061	1.4	1.5
2	12	0.143	0.035	3.7	.9
2	13	0.084	-0.101	1.7	2.1
2	14	0.064	0.043	1.7	1.2
2	15	0.097	-0.099	2.5	2.6
2	16	0.074	0.127	1.8	3.1
3	1	0.484	-0.494	7.3	7.5
3	2	0.296	0.273	7.3	6.7
3	3	0.235	-0.275	4.9	5.3
3	4	0.022	0.032	.7	.9
3	5	0.304	-0.205	6.0	4.0
3	6	0.248	0.086	5.7	2.0
3	7	0.155	-0.203	3.6	4.8
3	8	-0.088	-0.034	2.1	.8
3	9	-0.051	-0.063	1.2	1.4
3	10	0.253	0.055	4.0	.9
3	11	0.003	-0.134	.2	4.0
3	12	0.102	0.230	1.9	4.2
3	13	0.215	-0.151	5.6	3.9
3	14	0.209	0.180	4.2	3.6
3	15	0.278	-0.262	6.9	6.5
3	16	0.446	0.782	6.9	12.1

Band	Det	Amplitude Form 1	Amplitude Form 2	Separation of States (#S.D.) Form 1	Separation of States (#S.D.) Form 2
4	1	0.256	-0.047	6.6	1.2
4	2	0.147	-0.084	3.3	1.9
4	3	0.197	-0.031	2.3	.4
4	4	0.052	-0.072	1.3	1.8
4	5	0.119	-0.013	3.7	.4
4	6	0.316	-0.063	5.2	1.0
4	7	0.073	-0.017	3.1	.7
4	8	0.003	-0.083	.1	2.4
4	9	0.064	-0.023	1.9	.7
4	10	0.147	-0.013	5.0	.4
4	11	0.101	-0.017	4.0	.6
4	12	0.252	0.019	7.0	.5
4	13	0.063	-0.008	4.5	.6
4	14	0.087	-0.020	3.2	.7
4	15	0.114	-0.015	5.2	.6
4	16	0.371	0.029	9.7	.7
5	1	-0.018	0.060	.6	2.2
5	2	0.136	-0.105	3.6	2.8
5	3	-0.125	-0.067	4.6	2.5
5	4	0.113	-0.038	3.3	1.1
5	5	-0.183	-0.043	6.6	1.5
5	6	0.046	-0.085	1.4	2.6
5	7	0.017	0.143	.5	4.8
5	8	-0.074	-0.200	2.6	6.9
5	9	-0.085	0.023	2.7	.7
5	10	-0.086	0.744	2.7	21.7
5	11	-0.022	0.046	.9	1.9
5	12	0.006	0.061	.3	2.6
5	13	-0.083	0.004	3.4	.2
5	14	-0.079	-0.082	3.8	3.9
5	15	-0.211	-0.119	8.3	4.6
5	16	-0.017	-0.100	.7	4.3
7	1	-0.034	0.302	1.3	11.5
7	2	0.054	-0.293	1.8	9.7
7	3	-0.090	0.342	3.1	11.8
7	4	0.093	-0.273	3.4	9.9
7	5	-0.006	0.281	.2	10.8
7	6	0.123	-0.308	4.3	10.4
7	7	-0.040	0.960	.3	6.4
7	8	0.066	-0.345	2.6	13.5
7	9	-0.109	0.197	4.2	7.5
7	10	0.095	-0.461	3.3	15.1
7	11	-0.045	0.232	1.6	8.5
7	12	0.168	-0.297	5.3	9.1
7	13	-0.087	0.224	2.8	7.1
7	14	0.198	-0.085	6.6	2.8
7	15	-0.043	0.193	1.7	7.7
7	16	0.169	-0.253	5.5	8.2

** Negative amplitudes indicate level shifts with phase shifts of 180 deg. relative to B1D4 (Form 1) or B7D7 (Form 2).

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